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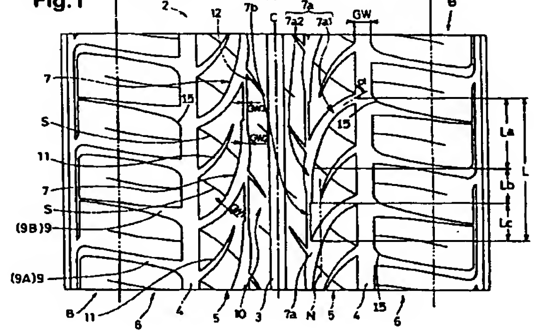
(54) Vehicle tyre

(57) A vehicle tyre comprises a tread portion (2) having circumferentially extending straight main grooves including a central main groove (3) on the tyre equator and an axially outer main groove (4) on each side thereof, first lug grooves (7) extending from the axially outer main grooves (4) towards the central main groove (3) but not reaching thereto, each of the first lug grooves comprising a first curved portion (7a1), a second curved portion (7a2) and a straight portion (7b) arranged in this order from the outer main groove (4) towards the central main groove (3), wherein the width (GW1) of the first curved portion (7a1) is in the range of from 60 to 80 % of the width (GW) of the outer main groove (4), the width (GW2) of the second curved portion (7a2)is not less than 25 % but less than 60 % of the width (GW) of the outer main groove (4), and the width (GW3) of the straight portion (7b) is not more than 25 % of the width (GW)of the outer main groove (4), the inclination angle α of each first lug groove with respect to the tyre circumferential direction being in the range of from 30 to 50 degrees at the outer main groove (4), and gradually decreasing therefrom in the first and second curved portions (7a1,7a2), and being substantially zero in the straight portion (7b), the depth of each first lug groove being smaller in the straight portion (7b) than the first curved portion (7a1). In addition corners (15) formed between the circumferential grooves and lateral grooves may be rounded by a conical face (16) the radius of curvature (R) of which gradually increases towards the radially outside of the tyre.

Fig.1



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Description

[0001] The present invention relates to a vehicle tyre having an improved tread portion capable of improving wet performance without sacrificing wear resistance.

[0002] Vehicle tyres such as pneumatic tyres for passenger cars, light trucks and the like are usually provided with circumferentially extending main grooves and lateral grooves to provide a good wet performance.

[0003] If the grooved area is increased, drainage from the ground contacting patch is increased and wet performance may be improved. But, wear resistance and uneven wear resistance tend to decrease.

[0004] It is therefore, an object of the present invention to provide a vehicle tyre in which wet performance can be improved without sacrificing wear resistance.

[0005] According to the present invention, a vehicle tyre has a tread portion comprising circumferentially extending straight main grooves including a central main groove on the tyre equator and an axially outer main groove on each side thereof, lug grooves extending from the axially outer main grooves towards the central main groove, but terminating before the central main groove, each of the lug grooves comprising a first curved portion, a second curved portion and a straight portion arranged in this order from the outer main groove towards the central main groove, wherein a width of the first curved portion is in the range of from 60 to 80 % of the width of the outer main groove, a width of the second curved portion is not less than 25 % but less than 60 % of the width of the outer main groove, and a width of the straight portion is not more than 25 % of the width of the outer main groove, an inclination angle of each lug groove with respect to the tyre circumferential direction being in the range of from 30 to 50 degrees at the outer main groove, and gradually decreasing therefrom in the first and second curved portions, and being substantially zero in the straight portion and the depth of each lug groove is smaller in the straight portion than the first curved portion.

[0006] Embodiments of the present invention will now be described in detail in conjunction with the accompanying drawings:

Fig.1 is a developed plan view of a tyre according to the present invention showing an example of the tread pattern;
Fig.2 shows a distribution of the depth of a lug groove along the groove centre line;
Fig.3 is a perspective view showing a rounded corner between a circumferential groove and lateral groove;
Fig.4 is a perspective view showing another example of the rounded corner;
Fig.5 is a perspective view of a rounded corner used as a reference in a comparison test;
Fig.6 is a perspective view of an angled corner used in the comparison test;
Fig.7 shows a simplified model for a unidirectional tread pattern; and
Fig.8 shows a simplified model for a bi-directional tread pattern used in a comparison test.

[0007] The tyre pattern of Fig.1 is for passenger cars.

[0008] Usually, a pneumatic tyre comprises a tread portion with a tread surface, a pair of axially spaced bead portions each with a bead core therein, a pair of sidewall portions, a carcass extending between the bead portions, and a tread reinforcing belt disposed radially outside the carcass. However, the present invention may be applied to non-pneumatic tyres.

[0009] In Fig.1, the tread portion 2 is provided with three main grooves extending straight and continuously in the tyre circumferential direction.

[0010] The three main grooves include a central main groove 3 extending on the tyre equator C, and two outer main grooves 4 disposed one on each side of the tyre equator C, thereby defining an axially inner region 5 between the central main groove 3 and each of the outer main grooves 4, and an axially outer region 6 between each of the outer main grooves 4 and the adjacent tread edge E.

[0011] Each of the main grooves 3 and 4 has a width GW in the range of not less than 2.5 %, preferably not less than 3 %, more preferably not less than 4 % of the tread width TW. The main grooves 3 and 4 are substantially all the same width in the example shown in Fig.1, but they may be differed.

[0012] Here, the tread width TW is the axial distance between the edges E of the tread surface or the ground contacting region under a standard condition in which the tyre is mounted on a standard rim and inflated to a standard load and then loaded with a standard load. The standard rim is the "standard rim" specified in JATMA, the "Measuring Rim" in ETRTO, the "Design Rim" in TRA or the like. The standard pressure is the "maximum air pressure" in JATMA, the "Inflation Pressure" in ETRTO, the maximum pressure given in the "Tyre Load Limits at Various Cold Inflation Pressures" table in TRA or the like. The standard load is the "maximum load capacity" in JATMA, the "Load Capacity" in ETRTO, the maximum value given in the above-mentioned table in TRA or the like. In case of passenger car tyres, however, 180 kPa is used as the standard pressure, and 88 % of the maximum load is used as the standard load.

[0013] The tread width TW is set at at least 80 % but preferably at most 95 % of the tyre width W.

[0014] In determining the tyre width W, in order to eliminate confusing decorative or protective protrusions provided on the tyre sidewall, a nominal tyre width appearing in a tyre size designation adopted in the above-mentioned tyre

standard can be used as the tyre width W. In the case of "195/60R14 85H" in metric system, for example, 195 mm is used as the width W.

[0015] Conventional tread width is about 75 % or less of the tyre width W. Thus, the tread width TW is greatly increased.

[0016] Further, the present invention is based on a negative ratio which is not more than 35 %, wherein the negative ratio is the ratio Sg/S of the total grooved area Sg in the tread surface to the total area S of the tread surface. Thus, the negative ratio Sg/S of the tyre is set in the range of not more than 35 %, preferably set in the range of from 25 to 35 %, more preferably 30 to 35 %.

[0017] As shown in the following Table 1, by increasing the tread width TW in relation to the tyre width W and decreasing the negative ratio the wear resistance is greatly improved. Thus, the negative ratio and the tread width are limited to be in the above-mentioned ranges.

Table 1

TW/W ratio (%)	75	75	80	80
Negative ratio (%)	40	35	40	35
Wear resistance(index)	100	110	110	120

[0018] Each of the axially outer main grooves 4 is disposed in the middle of the tyre equator C and tread edge E, whereby the tread is divided into four roughly equiwidth regions, namely, the above-mentioned axially inner regions 5 and axially outer regions 6. In Fig.1, the axially outer main grooves 4 are slightly offset towards the axially outside. Thus, the axially inner region 5 is slightly wider than the axially outer region 6.

[0019] Each of the axially inner regions 5 is provided with lug grooves 7 each extending axially inwardly from the outer main groove 4 and terminating before the central main groove 3.

[0020] Each of the lug grooves 7 comprises a curved portion 7a extending axially inwardly from the outer main groove 4 and a straight portion 7b extending circumferentially from the axially inner end of the curved portion 7a.

[0021] As to the inclination angle of the lug groove 7 with respect to the circumferential direction, the inclination angle α at the junction between the curved portion 7a and the outer main groove 4 is in the range of from 30 to 50 degrees, preferably 40 to 50 degrees, more preferably 42 to 48 degrees (in this embodiment 45 degrees), and the inclination angle gradually decreases to substantially 0 degrees from the axially outer end at the junction to the axially inner end at the connection point with the straight portion 7b.

[0022] The curved portion 7a includes a first curved portion 7a1 and a second curved portion 7a2.

[0023] The first curved portion 7a1 extends axially inwardly from the outer main groove 4, and this portion has a width GW1 of from 60 to 80 % of the width GW of the outer main groove 4.

[0024] The second curved portion 7a2 extends from the axially inner end of the first portion 7a1 to the straight portion 7b, and this portion has a width GW2 of not less than 25 % but less than 60 % of the width GW.

[0025] The straight portion 7b has a width GW3 of not more than 25 % of the width GW.

[0026] In the example shown in Fig.1, the width GW1 gradually increases from the outer main groove 4 towards the axially inside. However, the width GW2 gradually decreases towards the straight portion 7b. The width GW3 is constant. It is also possible that the width GW3 gradually decreases towards the axially inner end of the lug groove.

[0027] Fig.2 shows a distribution of the depth of the lug groove 7 along the groove centre line. The depth GD1 is constant and substantially the same as the depth of the axially outer main groove 4. The depth GD3 of the straight portion 7b is less than the depth GD1 of the first curved portion 7a1. The depth GD2 of the second curved portion 7a2 gradually decreases from the first portion 7a1 to the straight portion 7b so as not to form a stepped difference in the groove bottom. The depth GD3 is not more than 70 %, preferably 60 to 70 % of the depth GW of the main groove 4. In this example, the depth GD3 is constant, but it may be varied.

[0028] As the depth GD2 gradually decreases towards the straight portion 7b, support for the axially outwardly adjacent tread rubber gradually increases, and uneven wear thereof is improved.

[0029] The end of the straight portion 7b is connected to the curved portion 7a of the circumferentially adjacent lug groove 7, and the straight portion 7b is disposed such that its groove centre line is located axially inside the axial centre line N of the axially inner region 5. Therefore, the drainage from the tread centre region can be further improved.

[0030] Preferably, the circumferential length La of the first curved portion 7a1 is 0.5 to 0.6 times the circumferential length L of the lug groove, and the circumferential length Lb of the second curved portion 7a2 is 0.1 to 0.2 times the length L, and the circumferential length Lc of the straight portion 7b is 0.2 to 0.3 times the length L.

[0031] In this embodiment, each of the axially inner region 5 is further provided with second narrow lug grooves 11, auxiliary grooves 12 and sipes S.

[0032] Each of the second narrow lug grooves 11 is inclined in the same direction as the curved portion 7a and extends from one of the outer main grooves 4 towards the axially inside of the tyre and terminates before the first lug groove 7.

[0033] The sipes S are inclined in the reverse direction to the curved portions 7a at an angle of from 40 to 50 degrees with respect to the circumferential direction of the tyre. Each sipe S is a narrow slit or cut having a width of less than 1 mm, which is narrower than the grooves.

[0034] As shown in Fig.1, between the circumferentially adjacent first lug grooves 7, one narrow lug groove 11 and two sipes S are disposed.

[0035] Each of the auxiliary grooves 12 extends axially inwards from one of the first lug grooves 7 but terminates before the central main groove 3 so as to form a circumferentially continuously extending narrow rib 10 on each side of the central main groove 3. The auxiliary grooves 12 are inclined in the reverse direction to the first lug grooves 7 at angle of from 40 to 60 degrees with respect to the circumferential direction of the tyre. The axially outer end of each auxiliary groove 12 is opened to the first lug groove 7 in the curved portion 7a and near the junction of the circumferentially adjacent first lug grooves 7.

[0036] By providing those grooves 11 and 12 and sipes S, directivity of rigidity can be eliminated from the axially inner regions 5 and the wear resistance especially uneven resistance is thus improved. As the straight portion 7b of the first lug groove 7 has a minimum width GW3 and minimum depth GD3, the apparent rigidity of the rib 10 is increased, and uneven wear resistance can be increased.

[0037] The above-mentioned axially outer regions 6 are provided with lateral grooves 9 called shoulder grooves.

[0038] The shoulder grooves 9 extend from the axially outermost main grooves 4 to the tread edges E.

[0039] In the example shown in Fig.1, the shoulder grooves 9 include first shoulder grooves 9A and second shoulder grooves 9B arranged alternately in the circumferential direction. The first shoulder grooves 9A have a substantially constant width, but the second shoulder grooves 9B have a variable width which gradually decreases towards the tread edge E. The axially outer regions 6 are further provided between the shoulder grooves 9 with sipes extending almost parallel with the shoulder grooves 9.

[0040] Due to the gradually decreasing width of the shoulder grooves 9B, the rigidity of the shoulder blocks B increases towards the tread edges E, and tread shoulder wear can be improved.

[0041] The tread pattern shown in Fig.1 is a bi-directional pattern. However, the tread pattern may be modified into a unidirectional pattern by making it symmetrical about the tyre equator C. In such a case, the rotational direction is such that the lug grooves 7 contact the ground in the straight portion 7b prior to the curved portions 7a. In either case, symmetrical or asymmetrical pattern, it is possible to circumferentially shift a half tread pattern on one side of the tyre equator from the other half to avoid periodicity of tread pattern to reduce noise generated from the tyre during running.

[0042] In order to improve tyre noise and drainage, corners between circumferential grooves and lateral grooves, for example, corners 15 of the shoulder blocks B are rounded.

[0043] As shown in Fig.3, the corner 15 is provided with a conical face 16 the radius R of curvature of which gradually increases towards the radially outside of the tyre, wherein the radius R is measured in a plane parallel with the tread face.

[0044] In general, water flow from a circumferential groove to a lateral groove can be improved by rounding a corner formed between those grooves. If the corner is rounded with a cylindrical face as shown in Fig.5, air flow is also increased, and as a result, various noises called "pattern noise", "pumping noise" and the like increase. However, by using a conical face, it is possible to suppress the air flow while improving water flow.

[0045] The conical face 16 extends from the base of the block B or the bottom of the circumferential groove (main groove) to the top of the block. At the block top, the radius R of curvature is set in the range of from 5 to 10 mm, preferably 6 to 9 mm, more preferably 6 to 8 mm. At the groove bottom, the radius R of curvature is preferably set at substantially zero as shown in Fig.3. It is however possible that the radius R at the groove bottom has a positive value as shown in Fig.4. In this case, it is preferable to limit the value in the range of less than 1.5 mm, more preferably less than 1.0 mm in order to reduce noise.

[0046] In case of a bi-directional tread pattern as shown in Fig.1, obtuse-angle corners are preferably provided as the rounded corner 15. But it is also possible to use other corner shapes as the rounded corner 15.

[0047] In the case of a unidirectional tread pattern such as Fig.1 modified as explained above and Fig.7 presented as a simple model, it is preferable that toe-side corners are rounded but heel-side corners are angled.

Comparison Tests

[0048] Radial tyres for passenger cars having the tread pattern shown in Fig.1 and specifications shown in Table 2 were prepared and tested for wet performance and wear resistance.

Wet performance test:

[0049] A test car provided on all four wheels with test tyres was run on a wet asphalt road on a 100-metre-radius course provided with a five-millimetre-depth twenty-metre-long water pool. The running speed was increased stepwise, and the lateral acceleration (Lateral-G) was measured at the front wheels to obtain the average lateral-G in a speed range of from 50 to 80 km/h. The test results are indicated by an index based on Reference tyre 1 being 100. The larger the index, the higher the resistance to aquaplane.

Wear resistance test:

[0050] The test car was run for 8000 km (50 % of expressway, 35 % of highway, 15 % of mountain road) and thereafter the depth of the central main groove remaining was measured. The measured depths are indicate by an index based on Reference tyre 1 being 100. The larger the index, the better the wear resistance.

Tyre size: 205/65R15 94H
Rim size: 6JJ
Inner pressure: 200 kPa
Test car: Japanese 3000cc passenger car

The test results are shown in Table 2.

Table 2

Tyre	Ref.1	Ref.2	Ref.3	Ex.1	Ex.2
TW/W ratio	80%	80%	80%	80%	80%
Negative ratio	35%	35%	35%	35%	35%
Main groove					
Width (mm)	8.4	8.4	8.4	8.4	8.4
Depth (mm)	8.3	8.3	8.3	8.3	8.3
Lug groove					
Inclination angle α (deg.)	45	45	60	45	30
First curved portion					
Width (mm)	5	5	5	5	5
Depth (mm)	5.6	8.3	8.3	8.3	8.3
Second curved portion					
Width (mm)	4.2	4.2	4.2	4.2	4.2
Depth (mm)	5.6	8.3	8.3-5.6	8.3-5.6	8.3-5.6
Straight portion					
Width (mm)	2	2	2	2	2
Depth (mm)	5.6	8.3	5.6	5.6	5.6
Axially inner region					
Second lug groove	none	none	none	none	present
auxiliary groove	none	none	none	none	present
Sipe	none	none	none	none	present
Wet performance	100	110	100	110	115
Wear resistance	100	100	110	110	105

[0051] From the test results, it was confirmed that the tyres according to the present invention were improved in both the wet performance and wear resistance.

[0052] Further, in order to confirm the effect of the conical-rounded corner 15, a noise test and the above-explained wet performance test were conducted.

[0053] The test tyres used were pneumatic tyres having the same tread pattern except for corners, wherein the tread pattern was simplified as shown in Fig.8 to focus on the target noise, or air flow noise.

[0054] In the noise test, the test car was run in a test circuit course and noise was evaluated into ten ranks by the test driver's feeling. The larger the value, the better the noise performance.

[0055] The test results are indicated in Table 3A and Table 3B.

Table 3A

Tyre	Conv.	Ref.A	Ex.A
Corner	Fig.6	Fig.5	Fig.3
Radius R (mm)			
@ top	0	7	7
@ bottom	0	7	0
Groove depth(mm)	7	7	7
Wet performance	100	110	110
Noise performance	6	5.5	6

Table 3B

Tyre	Ex.A	Ex.B	Ex.C	Ex.D	Ex.E
Corner	Fig.3	Fig.3	Fig.3	Fig.3	
Radius R (mm)					
@ top	7	3	5	9	7
@ bottom	0	0	0	0	1
Groove depth(mm)	7	7	7	7	
Wet performance	100	95	97	105	100
Noise performance	6	6	6	5.5	5.5+

[0056] From the test results, it was confirmed that by providing conical-rounded corners 15, the wet performance could be improved without deteriorating the noise performance.

Claims

1. A vehicle tyre comprising a tread portion (2), provided with circumferentially extending straight main grooves including a central main groove (3) on the tyre equator and an axially outer main groove (4) on each side thereof, and first lug grooves (7) extending from the axially outer main grooves (4) towards the central main groove (3) but not reached thereto, characterised in that each of the first lug grooves (7) comprises a first curved portion (7a1), a second curved portion (7a2) and a straight portion (7b) arranged in this order from the outer main groove (4) towards the central main groove (3), wherein the width (GW1) of the first curved portion (7a1) is in the range of from 60 to 80 % of the width (GW) of the outer main groove (4), the width (GW2) of the second curved portion (7a2) is not less than 25 % but less than 60 % of the width (GW) of the outer main groove (4), and the width (GW3) of the straight portion (7b) is not more than 25 % of the width (GW) of the outer main groove (4), the inclination angle α of each first lug groove (7a1) with respect to the tyre circumferential direction being in the range of from 30 to 50 degrees at the outer main groove (4) and gradually decreasing therefrom in the first and second curved portions being sub-

stantially zero in the straight portion (7b) and the depth of each first lug groove being smaller in the straight portion (7b) than the first curved portion (7a1).

2. A vehicle tyre according to claim 1, characterised in that the straight portion (7b) of each of the first lug grooves (7) is connected to the curved portion of the circumferentially adjacent first lug groove (7).

3. A vehicle tyre according to claim 1 or 2, characterised in that the depth (GD1) of the first curved portion (7a1) is substantially the same as the depth (GW) of the outer main groove (4), and the depth (GD3) of the straight portion (7b) is not more than 70 % of the depth (GW) of the outer main groove (4), and the depth (GD2) of the second curved portion (7a2) gradually decreases from the first curved portion (7a1) to the straight portion (7b).

4. A vehicle tyre according to claim 1, 2 or 3, characterised in that the circumferential length (La) of the first curved portion (7a1) is 0.5 to 0.6 times the circumferential length (L) of the first lug groove, the circumferential length (Lb) of the second curved portion (7a2) is 0.1 to 0.2 times the circumferential length (L) of the first lug groove and the circumferential length (Lc) of the straight portion (7b) is 0.2 to 0.3 times the circumferential length (L) of the first lug groove.

5. A vehicle tyre according to claim 1, 2, 3 or 4, characterised in that second lug grooves (11) and sipes (S) are provided between the circumferentially adjacent first lug grooves, the second lug grooves (11) being inclined in the same direction as the curved portions (7a1,7a2) and not connected to any first lug groove (7), and the sipes (S) being inclined reversely to the curved portions (7a1,7a2) at an angle of from 40 to 50 degrees with respect to the circumferential direction of the tyre.

6. A vehicle tyre according to any of claims 1 to 5, characterised in that the tread portion (2) is provided with lateral grooves extending from the main grooves to form corners (15) between the lateral grooves and the main grooves, and at least some of said corners (15) are rounded by a conical face (16) the radius of curvature (R) of which gradually increases towards the radially outside of the tyre.

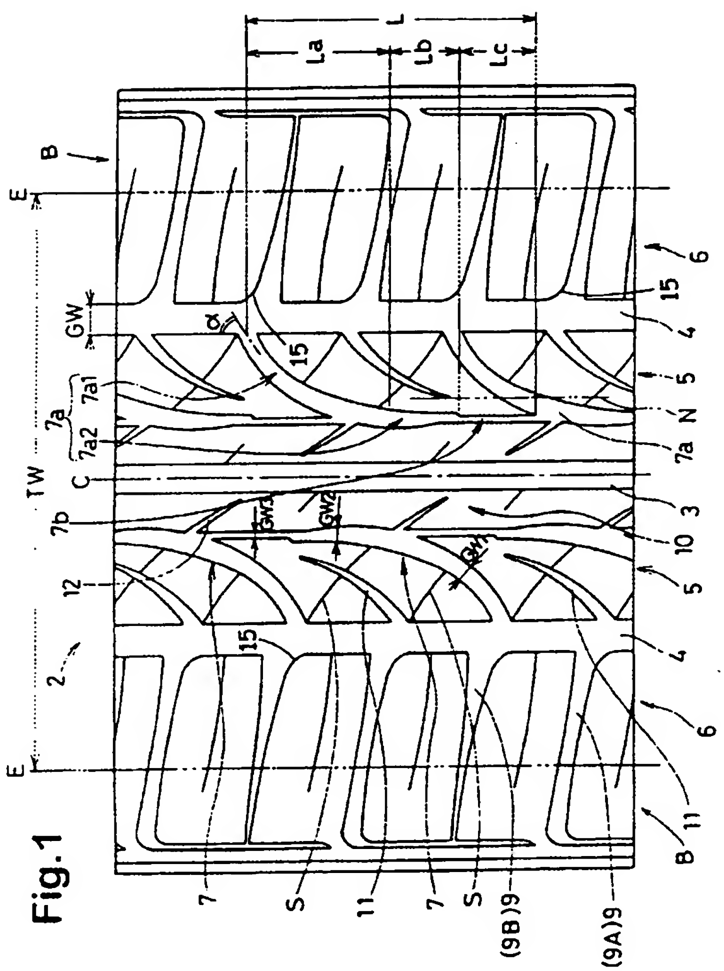
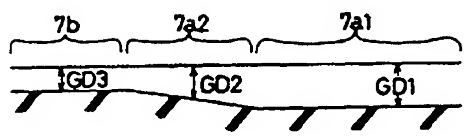


Fig.1

Fig.2



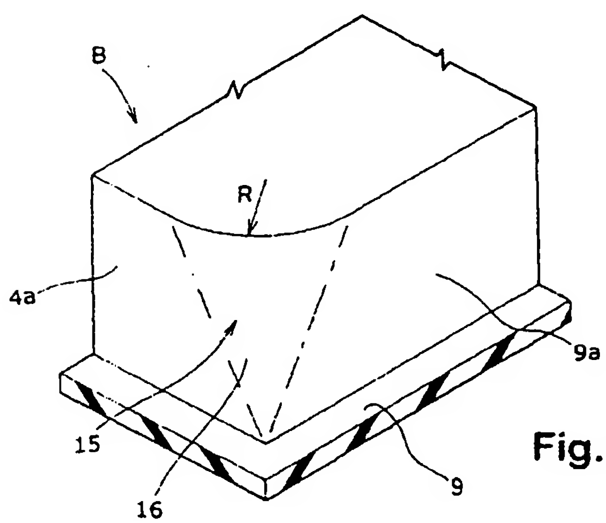


Fig.3

Fig.4

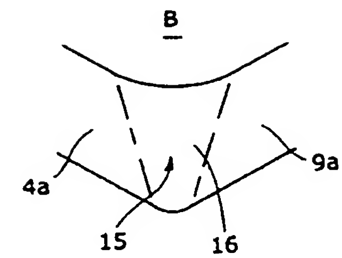


Fig.5

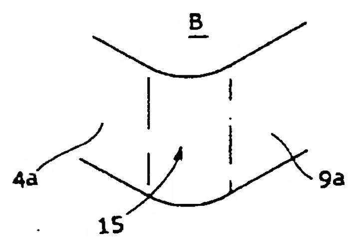


Fig.6

Prior Art

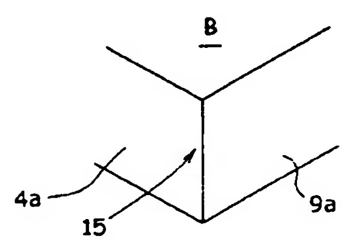


Fig.7

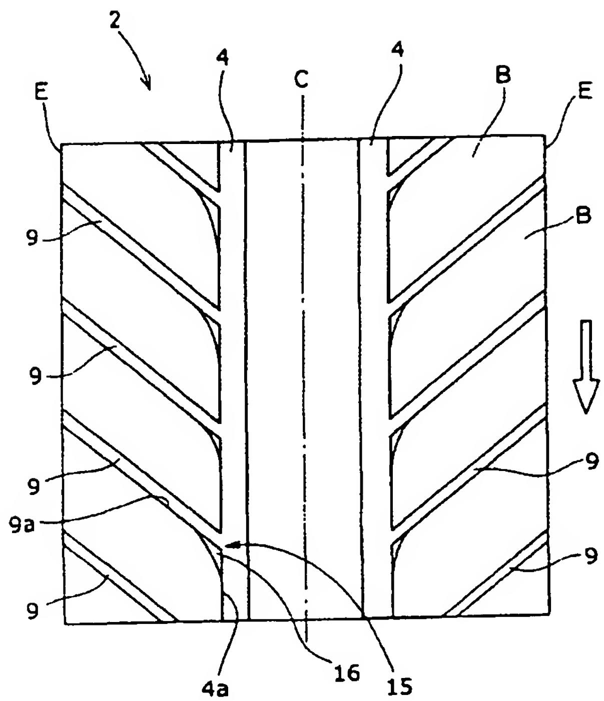


Fig.8